Hot rolled formable grades from SAIL: Present status and future trends

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Steel Making (BOF) → Secondary Refining (Ladle Furnace) → Continuous Casting → Hot Strip Rolling (TMCP) → New Grades (HSFQ 450 / 500 / 550)
Product characteristics

- High Strength and toughness
- Formability
- Cleanliness
- Weldability

Achieved through innovative alloy design with higher Si and lower Nb
Limitation of Existing High Strength Hot Rolled Grades

- Higher YS achieved by Nb addition
- Si restriction < 0.05%

High YS/UTS > 0.92
High strength Formable Quality (HSFQ) steel (BSL)

- Series of HSFQ grades (HSFQ 450/500/550) developed with innovative alloy design
  - Nb (0.025-0.045 %) and Si (0.25-0.35%)
- All round improvement in formability with Reduced cost of production
  - HSFQ 450 (lower YS/UTS : 0.86 max, Higher % El: 32 and Higher Hole Expansion : 150 % min)

Si: 0.045 %
Si: 0.33 %
HSFQ 500 / 550

Commercial heats Nb (0.02-0.045 %) & Si (0.25-0.30 %)

![Graph showing the relationship between Si content and grain size.](image)

- The plotted line is given by the equation $y = -12.434x + 6.0427$.
- $R^2 = 0.9795$

- Nb ~ 0.04%

![Image of ferrite grain size](image)

- Average ferrite grain size ~ 2.8 µm (0.042% Nb)
- (uniform across the strip thickness)

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Breakthrough in technology for development of “cost effective ultra fine grained steel”
Advantages

- It allows the users to increase the strength of the finished component
- Alternatively it will provide opportunity to reduce sheet thickness to make a design effective item
- Products more profitable and competitive by increasing the output from each tonne of steel

Stronger, lighter and safer product

Strength & Formability of these grades expand scope for fabrication
Products can be manufactured by press forming rather than welding
Applications

- Hydro-formed Sections
- Roll-formed Sections

- Prefabricated Structural sections
- Automotive Components
- Tubes
- Shelves
- Silos and containers
# Diversified applications (HSFQ)

<table>
<thead>
<tr>
<th>Customer</th>
<th>Appliances</th>
<th>Chennai</th>
</tr>
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<tbody>
<tr>
<td>EN 10028 P355 N</td>
<td>(YS: 355 MPa, UTS: 490-630 MPa, % El: 22, CIE : 20 J at -20 C)</td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td>Large (1000 litre) cylinder</td>
<td></td>
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- **First manufacturer of such large cylinders in South Asia**

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<thead>
<tr>
<th>Customer</th>
<th>Hero Cycles</th>
<th>Ludhiana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>High Tensile CR Structurals (UTS : 500 Mpa min.)</td>
<td></td>
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<thead>
<tr>
<th>Customer</th>
<th>Ashok Leyland</th>
<th>Hosur</th>
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<tr>
<td>Application</td>
<td>Long / Cross Member</td>
<td></td>
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<td></td>
<td>Completely switched over to HSFQ 450</td>
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80 Ksi (HSFQ 550) : Highest auto chassis grade for HCV developed
Limitation of HSS / AHSS

- **ULSAB / ULSAB AVC**
  New advanced grades and innovative processes – Lightweight safe vehicle

- **Use of HSS / UHSS**
  Stamping complex structural automotive components - Difficult and capital-intensive

- **Limited formability / Drawability with increased strength**
  Especially springback – Restricts Workability

- **Introduction of innovative processes like hot stamping, hot forming, hydroforming**
  To overcome processing drawbacks with HSS/AHSS

*Paradigm shift in auto segment from product to process*
Innovative processing techniques

Traditional Stamping
- at Room Temperature
- on a mechanical press

Hot Forming
- at elevated temperatures
- on a hydraulic press + Air Cooling

Hydro-forming
- at room temperature
- with force of water or hydraulic fluids

Hot Stamping
- at elevated temperatures
- on a hydraulic press with a water-cooled die for quenching
Hot Stamping

- Evenly heating a steel blank,
- Forming it at precise forming pressures
- Cooling it at controlled temperatures in die

Hot stamping = forming + hardening
combined in a single operation
Boron treated steel for Hot Stamping

- Retards the nucleation site of ferrite at the austenite grain surfaces,
- increases hardenability of steels

Role of Differential Cooling
Advantages

- Tensile strength of hot stamped steel can reach 1500 MPa offering ultrahigh strength and lower weight.
- High hardness (up to 48 Rockwell C) and improved wear resistance.
- The process minimizes springback.
- Good repeatability in long production runs.
- Hot stamping provides excellent plastic formability in HSS.
- Low carbon content, favorable for welding.
- Production of complex shapes in a single hit.
Conclusion

- Development of High Strength Formable Quality (HSFQ) hot rolled steel (YS: 460/500/550 MPa min)
- Si in presence of Nb has enhanced grain refinement (<3 micron) in hot rolled steel
- Initiative for development of hot stamping grades
Thank you